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ABSTRACT

This study was designed to investigate and analyze specific instructor and student behaviors in introductory and advanced laboratories of five science disciplines (botany, chemistry, geology, physics, and zoology) at a major midwestern university. The instructor sample involved teaching assistants from various science departments. The student observations were made by randomly selecting students from the laboratories and observing their behaviors for ten minutes at a time. The Science Laboratory Interaction Categories system was designed and used to code the instructor and student behaviors. Data were analyzed using the process of macroanalysis. The instructor and student behaviors were not consistent among science disciplines or among the introductory and advanced level courses within science disciplines. It appears that even at the college level students are performing cookbookish laboratories with the role of the instructor a very mechanical one. (BB)

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The University of Iowa

February 1979

technical report 16

A Comparative Study of Instructor and Student Behaviors and the Role of the Instructor in Introductory and Advanced Laboratories of Five Science Disciplines at the University Level

by

William C. Kyle, Jr., James A. Shymansky, John E. Penick

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A Comparative Study of Instructor and Student Behaviors and the Role of the Instructor in Introductory and Advanced Laboratories of Five Science Disciplines at the University Level

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INTRODUCTION

In 1965, Edmund J. Amidon stated that "what the field of professional education really needs is college teachers who are willing to analyze their teaching and who have the tools to do it" (p. 5). Educational researchers have given much attention to the evaluation of teaching at all levels through a variety of methods. We frequently hear about student evaluations or ratings of instructors, to which Gage (1961) and Mouly (1969) make reference to the dangers and disadvantages of relying on such rating systems; and, observation techniques of identifying effective teaching behaviors. Seldom however, is reference made to observing student behaviors as a means of measuring teacher effectiveness.

The literature on effective college teaching is not definitive. Dunkin and Biddle (1974) have suggested several reasons for the failure of educational researchers to define effective teaching despite over sixty years of study. They suggest that the single most significant shortcoming is the failure to observe teaching activities. Methodological problems, however, continue to haunt studies of teacher and student behavior through direct observation. These problems include, but are not limited to: which behaviors to record; when to record selected behaviors; and, to whom or for whom are the observed behaviors directed towards (Brophy and Good, 1974; Dunkin and Biddle, 1974; Good, Biddle and Brophy,1975). Yager (1978) notes that through nonquantitative research involving open-observations reporting the behaviors of a single student,

a small group, or a class may provide useful insights into the moment-to-moment microdynamics of teaching. Yager further states that the reporting of such observations and conclusions from a small data base requires skill and courage; and, further, that the newly emerging field of ethology applied to education may afford opportunities for desirable research. Similarly, in establishing the priorities for research in science education utilizing the Delphi technique (Butts et al., 1978) the research category "analysis of classroom teaching behaviors that facilitate science learning" ranked second among the thirty-five generic statements generated by the NARST membership.

After an extensive review of the literature, it appears as though college science departments have not yet determined how to analyze (even if they should desire to) their own teaching behaviors. Perhaps this is desirable in that it provides science educators the opportunity to, and the responsibility of, objectively analyzing and reporting classroom and laboratory behaviors to the respective science departments. This study provides the initial groundwork and anticipates future cooperation among science educators and science departments to ensure that students receive, and instructors as facilitators of knowledge provide, the best possible learning environment. An essential aspect of that learning environment is the instructor-student behaviors and interactions.

In order to make objective instructor and student evaluations, educators must be cognizant of the behaviors which are being

exhibited in the science laboratory. Objective, detailed, quantitative descriptions of instructor-student interactions in science laboratories can now be obtained by systematic observational techniques using interaction analysis. Instructor and student behavior may be studied at different levels depending upon the purpose to be served by the investigation. In this initial study at the college level, behaviors are observed, described and classified while no effort is made to induce changes, to study the underlying conditions, or to find correlates. Thus, with the particular aim of describing and analyzing instructor and student behaviors in college science laboratories, the elements of the conceptual context are verbal behavior, laboratory manipulation and verbal and non-verbal interactions among instructors and students.

PURPOSE OF THE STUDY

This study was designed to investigate and analyze specific instructor and student behaviors in introductory and advanced laboratories of five science disciplines - - botany, chemistry, geology, physics, and zoology - - at a major midwest university. Introductory laboratories accompanied introductory courses which are regarded by the specific science departments as core courses and, as such, prerequisites to the advanced courses. Advanced laboratories accompanied those courses which undergraduate and graduate students elect to take as part of a degree program after successfully completing the required prerequisite.

This study involved two component parts - - the development of an interaction analysis system capable of objectively and systematically assessing instructor and student behaviors in college science laboratories (see Kyle, Penick and Shymansky, 1978); and, the subsequent coding and analysis of such laboratory behaviors. The specific questions addressed in this study are:

1. Do mean behavior scores of specific instructor and student behaviors differ among the introductory and advanced level laboratories within the five science disciplines?
2. Do mean behavior scores of specific instructor and student behaviors differ among the five science disciplines?
3. Do pattern scores (τ) of selected MACROanalytic (Shymansky et al., 1975) instructor and student patterns differ among the introductory and advanced level laboratories within the five science disciplines?
4. Do pattern scores (τ) of selected MACROanalytic instructor and student patterns differ among the five science disciplines?

The behavior score, the frequency of occurrence of each individual instructor and student behavior as observed using the Science Laboratory Interaction Categories (Teacher Version, Shymansky et al., 1976; Student Version, Penick et al., 1976) (see Table 1 and 2 respectively), is the dependent variable analyzed for each instructor and student observation. The pattern

TABLE 1

SCIENCE LABORATORY INTERACTION CATEGORIES (SLIC) - TEACHER*

X -- Asks extended thought questions; requires students to synthesize ideas; includes questions designed to elicit predictions, hypotheses, explanations, or evaluations.

Q -- Asks factual recall questions; no student synthesis required; includes questions asked for descriptions of what was done.

D -- Demonstrates procedure; any teacher manipulation intended to tell the student what to do or how to do an activity.

G -- Gives directions; verbal behaviors which tell the student what to do or how to do an activity; includes rhetorical questions.

S -- Shows, illustrates; any teacher manipulation of equipment done for the purpose of transmitting non-directive information (does not tell student what to do or how to do an activity).

T -- Transmits information; verbally transmitted non-directive information without use of manipulative materials.

P -- Positive reinforcement; positive evaluation of behavior.

N -- Negative Comment or Behavior; negative evaluation of behavior.

B -- Active observation; receiving information from the student through the direct manipulation of or reference to material or objects.

A -- Acknowledges student behavior; non-evaluative statements or gestures used to indicate attentiveness to student behavior; includes repeating or rephrasing student responses.

L -- Listens to students; receiving information from student through discourse directed at the teacher.

O -- Passive observation; watching or listening to students in situations where teacher is not directly or actively involved.

R -- Reads and/or writes; any lesson-related reading or writing done by the teacher, with or without students directly involved.

M -- Management of lesson; management or clerical activity related to the administration of the lesson; includes getting supplies, making assignments, etc.

Z -- Non-lesson-related behaviors; any teacher behavior which does not facilitate the activities or lesson taught.

*Developed by J. A. Shymansky, J. E. Penick, L. J. Kelsey, G. W. Foster; The Science Education Center, The University of Iowa, Iowa City, Iowa, 1976.

TABLE 2

SCIENCE LABORATORY INTERACTION CATEGORIES (SLIC) - STUDENT*

S -- Shows; manipulating materials with the purpose of transmitting information to teacher or student; includes showing how to do something as well as demonstrating the results of doing something.

E -- Manipulates apparatus, observes activity; experimenting, manipulating equipment, observing experiment in progress; other activity with lesson-related non-written materials.

T -- Transmits information; conveying ideas, thoughts, questions without manipulating equipment. Includes giving directions, feedback answering questions, or other behavior which transmits information. Includes rhetorical questions.

Q -- Ask questions; any attempt to gather information verbally from teacher or students.

L -- Listens; active behavior of receiving information from teacher or students.

O -- Observes; passive behavior allowing student to watch actions of teacher or students. Includes listening to conversations in which the subject is not directly involved.

R -- Reads lesson-related material; any reading related to the lesson or course goals. Includes notes that have been written by the student; notes written by another student; a textbook or lab manual.

W -- Writes notes or records data; note taking, recording of data, answering of questions, or other writing directly related to the lesson. Does not involve transmitting information immediately to another person.

M -- Gets supplies, moves around the room; moving around the room in a purposeful fashion, getting supplies, putting away materials, or other mobile activities which facilitate the lesson.

Z -- Non-lesson-related behavior; behavior which does not facilitate the goals of the particular course or lesson, including interactive as well as non-interactive behaviors.

* Developed by J. E. Penick, J. A. Shymansky, K. M. Filkins, W. C. Kyle, Jr.; The Science Education Center, The University of Iowa, Iowa City, Iowa, 1976.

score is the dependent variable being analyzed for each instructor and student MACROanalytic pattern selected. The pattern score is the mathematical result of the Pattern Analysis Coefficient (Kyle, 1977) which was developed specifically for this study. The derivation of T is in the Methods of Analysis of Collected Data section of this paper.

Ultimately, our aim is not to evaluate individual instructors, but to collect objective and systematic data to be used as feedback to the instructors observed with the goal of improving college science laboratory instruction.

PROCEDURES AND SAMPLE

Data Collection Procedures

The Science Laboratory Interaction Categories (SLIC) were designed specifically for use in science laboratories and can be used to observe and analyze the various parameters of activity-centered and vocational education classrooms. Complete descriptions of the individual behaviors and ground rules for using the Science Laboratory Interaction Categories - - Teacher and Student versions - - are provided in Appendices A and B of Science Education Center Technical Report #15 (Kyle et al., 1978).

During the Spring 1976 semester, five science departments at a major midwest university agreed to have science educators observe instructor and student behaviors in introductory and advanced laboratories. The departments and specific laboratories are as follows:

A. Botany

1. Introductory - Introduction to Botany

2. Advanced - Evolution of Land Plants

B. Chemistry

1. Introductory - General Chemistry

2. Advanced - Intermediate (Organic) Chemistry

C. Geology

1. Introductory - Man and His Physical Environment

2. Advanced - Principles of Paleontology

D. Physics

1. Introductory - College Physics or General Astronomy

2. Advanced - Electronics, Introductory Physics II, Intermediate Laboratory or Astronomical Laboratory

E. Zoology

1. Introductory - Principles of Animal Biology

2. Advanced - Parasitology

Each instructor and student observation included only the hands-on portion of the laboratory activities since observers were prohibited from coding pre- and post-laboratory discussions. The ninety-eight hours of direct observation of instructor and student behaviors in the five science disciplines occurred between March 1st and April 16th, 1976. Each of the ten courses in which instructor and student behaviors were observed had numerous laboratory sections thus, the behaviors which instructors and students exhibit can not directly be related to differences in individual instructors (i.e., instructor style); but, rather,

reflect differences or similarities among level (i.e., introductory or advanced), or among disciplines (i.e., botany, chemistry, geology, physics and zoology).

Observers using the SLIC system code the behavior of instructors or students in a laboratory every three seconds using codes representing three dimensions of the interaction. These three dimensions are : (1) What is the specific nature of the behavior being exhibited by the student? (manipulate apparatus, asks questions, reads, etc.); (2) To whom is a specific behavior being directed? (to a teacher or to a student, and at how many individuals is the interaction being directed); and, (3) The sex of the student or teacher to whom the behaviors are being directed (same, opposite, or mixed group if two or more persons of opposite sexes involved).

The observers were concerned with accuracy and precision of measurement. The reliability of a measure is the statement which represents the various sources of error in the repeated measurement of a single phenomenon or the consistency in which an individual performs the same task over a period of time (Brown and Webb, 1968, p. 37). Thus, the reliability in this context is a property of the measuring and not of the instrument. It is only when the instrument has been used to collect data that we can speak sensibly about reliability. Each observer's score on a master-coded video tape was compared to a criterion code and an agreement index was computed using the Scott Coefficient, π (Flanders, 1965). The average Scott Coefficient for the

instructor observers was π = .75. The average Scott Coefficient for the student observers was π = .76.

It is obvious, however, that in order to collect reliable data with an observation instrument that the observational instrument must be valid, that is, the observation categories must be measuring what they purport to measure as established by the definitions and ground rules set forth by the developers. An instrument can produce scores or measures which are reliable or unreliable depending upon the manner in which the instrument is used, the subjects observed, the skill of the observer, and the number and length of observation periods (Rowley, 1976).

Before any interpretation of the data transpire, an important ground rule of the SLIC category system should be discussed. The position of the behaviors in the SLIC system is significant in that the more active category (or the one in which the materials or equipment play a greater role in the interaction) appear first in the listing. In the event that two categories appear to be occurring simultaneously, the behavior appearing higher on the category listing should be recorded. An alternative to this can be to alternate codes when two things are happening simultaneously. An extension of this same ground rule says that if you can't discriminate between two behaviors, for instance, if you're not sure whether a student is listening or merely observing, then you code it as the higher of the two categories, that is, listens. This concept of coding a behavior as the higher of the two categories, is generally a conservative

strategy in that the active category is more than likely a more desirable behavior than the passive category.

The Instructor Sample

The instructor sample was comprised of teaching assistants from the various science departments. Permission was obtained prior to the actual live coding from each of the five department chairpersons to assess the behaviors in introductory and advanced laboratories in which teaching assistants were responsible for instruction. The teaching assistants were informed in advance that observers would be collecting data in some of their laboratories but they were not aware of the specific nature of the observations. Teaching assistants were not given any advance notice as to wher observations would be made, if any, in their particular laboratory sections.

It was assumed that instructor laboratory behaviors can be revealed by observable occurrences which may be systematically and objectively measured and recorded; and, compared to other factors influencing instructor behavior, the presence of observers does not affect instructor behavior. In fact, it should be reasonable to assume that any response on the part of the instructor to the presence of observers would be a positive response in terms of behavior. Thus, it can be assumed that the behaviors observed reflect the best teaching performance of individual teaching assistants.

Additional data collected on teaching assistants includes the number of years of teaching experience (Table 3), their educational background (United States or foreign) (Table 4), and the highest degree currently held (Table 5).

TABLE 3

Average Years of Teaching Experience for Observed Teaching Assistants

Department	Introductory Laboratories	Advanced Laboratories
Botany	2.19	3.00
Chemistry	2.33	1.82
Geology	1.47	2.00
Physics	2.67	2.19
Zoology	2.89	1.70

TABLE 4

Educational Background for Observed Teaching Assistants

	Introductory Laboratories		Advanced Laboratories	
Department	Percent U.S. Educated	Percent Foreign Educated	Percent U.S. Educated	Percent Foreign Educated
Botany	100	0	100	0
Chemistry	33	67	46	54
Geology	100	0	100	0
Physics	100	0	80	20
Zoology	80	20	100	0

TABLE 5

Highest Degree Held by Observed Teaching Assistants

Department	Introductory Laboratories			Advanced Laboratories		
	B.A./B.S.	M.A./M.S.	Ph.D.	B.A./B.S.	M.A./M.S.	Ph.D.
Botany	86%	14%	0%	0%	100%	0%
Chemistry	100%	0%	0%	45%	55%	0%
Geology	76%	24%	0%	100%	0%	0%
Physics	67%	33%	0%	20%	80%	0%
Zoology	10%	70%	20%	60%	40%	0%

Each instructor observation lasted a total of thirty consecutive minutes and was regarded as an independent observation. That is, if more than one observation was made of a single instructor, each observation of that instructor was regarded as an independent observation. A total of eighty-four instructor observations were made.

The Student Sample

Student observations were made by randomly selecting students from the various laboratories and observing their behaviors for ten minutes at a time. It was assumed that student laboratory behaviors can be revealed by observable occurrences which may be systematically and objectively measured and recorded; and, compared to other factors influencing student laboratory behaviors, the presence of observers does not affect student behaviors.

Each student observation was regarded as an independent observation. That is, if more than one observation was made of a single student through random selection, each observation of that student was regarded as an independent observation. A total of three hundred thirty-six student observations were made.

Methods of Analysis of Collected Data

As the number of systems for use in analyzing student and teacher classroom behaviors and interactions increased (Simon and Boyer, 1974), the techniques for analyzing the data remained relatively stable. H.H. Anderson et al. (1945, 1946) used the first interactive ratio, the dominative-integrative ratio, to determine the interactive role among students and teacher. Withall (1951) refined Anderson's system and he termed his dimensions learner-centered and teacher-centered. The Flanders System of Interaction Analysis refined data collecting so that coded tallies could be recorded systematically. He also sequenced the behaviors in pairs thus developing the two-by-two contingency matrix. This matrix analysis (Flanders, 1960, 1965; Flanders and Amidon, 1963) represented the only major technique for analyzing interaction analysis until Campbell's (1973) macro-analysis was reported.

Flanders' matrix was developed to provide more substantial feedback to teachers regarding their classroom behaviors. The matrix is used both to indicate in graphic form an interaction

pattern and to tabulate the results. The numbers are tallied into a matrix by pairs, that is, the row selected represents the first number of the series, the column the second. Thus, each mark on the matrix represents two numbers of the series, and each number is recorded twice.

The original matrix produced 100 cells (10 x 10), while various modifications of Flanders' system produced matrices with 400-900 cells (Campbell, 1973). The modifications of the Flanders' system made concerted efforts to be more precise by adding categories. However, the majority of matrix cells contained no data and thus, the system became less and less useful.

Campbell (1973), in an attempt to view interactive dialogue in larger and larger units developed the process of macroanalysis. "Macroanalysis is a process of analyzing interactive data into units of three or more tallies. No matrices are utilized and all sequences involve nine or more seconds of dialogue" (p. 2). It is important to note that macroanalysis produces quantitative tabulations for the full array of results. Many researchers prior to the conceptualization of macroanalysis had tried to construct three-, four-, and five-tally patterns from two-tally data (Amidon and Amidon, 1967; DeLucia, 1971; Hall, 1969). Rather than extracting and attempting to validate inferences, macroanalysis analyzed actual interactive data.

Shymansky et al. (1975) state that:

> . . . macroanalytic techniques provide the opportunity to deal with the synergetic character of observational data, that aspect of the actual classroom which cannot be captured in the individual observational codes but is somehow bound up in the total of the patterns of behavior. (p. 221)

Shymansky et al. (1975) refined the macroanalysis technique and have since referred to the modification as MACROanalysis to distinguish it from the original macroanalysis proposed by Campbell. Campbell's macroanalysis was based on a three-second coding cycle where every tally was sequenced. A substantial proportion of the total number of three-, four-, or five-tally sequences contain repeated tallies. Shymansky et al. note that "implicit in this treatment of repetitive codes within the five-tally sequence is a definition of behavior pattern which states that no change in behavior need occur over the time period involved" (p. 222) Shymansky et al. therefore modified Campbell's macroanalytic technique by reducing uninterrupted chains of identical behavior into single units (XAAAX ⇒ XAX; BBBADDAABB ⇒ BADAB). Thus, MACROanalysis is more capable of directly identifying broader patterns of teacher and student behavior. Shymansky et al note that:

> When used in conjunction with a frequency count of individual behavior codes, the MACROanalysis technique not only increases the amount of information obtained from raw observational data but appears to be far more efficient than the standard macroanalysis procedure. (p. 226)

A frequency report of each individual instructor and student behavior along with identification of the top seventy-five three-tally collapsed sequential patterns for each instructor and student observation was obtained with a computer program designed to identify behavior patterns in observational data (MACRO 1) (Shymansky, Penick and Wortman, 1977).

Although the basic program function of MACRO 1 "... is the identification of patterns, several types of patterns as well as several characteristics of the patterns are built into the program or can be called at the user's option" (Shymansky, Penick and Wortman, 1977, p. 2). The pattern length can be specified to contain from one to five characters (a grouping size or pattern length of one code amounts to a simple frequency report of individual codes). After deciding the pattern length, the user has the option of formulating patterns which include repetitive characters or collapsing repetitive characters within the sequence. Collapsing repetitive characters (MACROanalysis) has the effect of reducing long strings of repetitive codes into a single code within behavior patterns. Thus, a three-code pattern is able to be analyzed in terms of the frequency of occurrence of the pattern and the total length of time which three different behaviors occur sequentially in the laboratory.

The identification process for the top seventy-five three-tally collapsed sequential patterns includes the frequency of occurrence of each pattern (obviously, not all patterns will occur with the same frequency); the average number of tallies for each behavior; and, the average total number of tallies for the collapsed sequential pattern. For example, the observed student pattern EME may account for 16.90% of the frequency time for an individual student observation; the behavior E for that observation may occur on the average 4.5 tallies, the behavior M may occur on the average 1.2 tallies, and the behavior E may occur

on the average 5.3 tallies. Thus, the average total number of tallies for a collapsed sequential pattern is 11; or, in terms of real time the pattern occurs 16.90% of the time for an average length of thirty-three seconds (each tally represents a three-second duration).

The identification of the top seventy-five three-tally collapsed sequential patterns revealed 92.5% of all instructor behaviors exhibited and 98.8% of all student behaviors exhibited. Twelve specific instructor patterns and eight specific student patterns were selected for analysis. After the specific patterns were selected, the raw macroanalysis pattern data for instructors and students were sorted with a shuffle program. Since this program operates on the basis of pre-selected patterns, if specific patterns do not occur for an observation, the frequency of occurrence; number of tallies for each behavior; and total number of tallies is reported as zero.

Data were analyzed on The University of Iowa - Iowa State University Computer Link using the Statistical Analysis System (SAS) (Barr et al., 1976). This link between the IBM 360/65 at The University of Iowa and the IBM 370/158 at Iowa State University allows shared access by the users of both university centers, and makes it possible to provide more program packages since costs and support are shared. SAS is currently maintained at Iowa State University, Ames, Iowa; and, programs have been run under release 76.4 of SAS at The University of Iowa.

The individual instructor and student behavior analysis and the selected instructor and student pattern analysis was accomplished by using a General Linear Model (GLM) procedure. The model source statement gives the dependent variables and independent effects. Due to unequal cell frequencies orthogonality is destroyed. A condition for orthogonality is that the number of observations in each possible combination of treatment is the same (Hayes, 1973). Thus, the Type IV sum of squares (SS) is used as described in SAS-76 (Barr et al., 1976). The level treatment SS, the department treatment SS, and the level by department interaction SS do not sum to the model SS when using the Type IV SS due to the unequal cell frequencies and the interaction effects (these are controlled through the use of Type IV SS). The corrected total reported for each analysis is equal to the number of observations in the data set minus one (N-1).

The behavior score is the dependent variable being analyzed by the General Linear Model Procedure for each instructor and student behavior. The behavior score is the frequency of occurrence of each individual instructor and student behavior.

The pattern score is the dependent variable being analyzed by the General Linear Model Procedure for each instructor and student pattern selected. The pattern score is the mathematical result of the Pattern Analysis Coefficient (Kyle, 1977) which was developed specifically for this study and is represented by the Greek letter tau (τ). The derivation of τ is as follows:

$$s = \frac{\Sigma f\, l}{n}$$

where

f = frequency of each observable occurrence of the pattern

l = the total length of each observable occurrence of the pattern in tallies

and

n = the number of students exhibiting the pattern.

Thus, s represents the mean score for students exhibiting a specific pattern. The pattern score, τ, is the product of the mean score (s) and the proportion of students that exhibit the pattern (p). Hence,

$$\tau = s \cdot p \quad .$$

A statistical analysis based on τ provides for a comparison of the selected pattern based on the entire laboratory, since τ represents the mean score for all students observed in a given laboratory. Thus, the Pattern Analysis Coefficient, τ, can be rewritten as:

$$\tau = \frac{p \sum f\, l}{n} \quad .$$

FINDINGS OF THE STUDY

The four specific questions which were raised earlier in this paper actually reflect a number of hypothetical statements regarding each individual instructor and student behavior and each selected pattern.

Table 6 contains a summary of the frequency of occurrence (in percents) of individual instructor behaviors for each level and department. The ANOVA results for each behavior's main effects are summarized in Table 7. The data revealed significant differences in the mean behavior score for T (transmits information), O (passive observation), and Z (non-lesson related behavior) among the introductory and advanced level courses within the five science disciplines. Between the five science disciplines the data revealed significant differences for thirteen of the instructor behaviors. No differences were evident for N (negative reinforcement) or Z (non-lesson related behaviors).

Table 8 contains a summary of the frequency of occurrence (in percents) of individual student behaviors for each level and department. The ANOVA results for each behavior's main effects are summarized in Table 9. The data revealed significant differences in the mean behavior score for E (experimenting), L (listens), O (observes), R (reads), and W (writes notes or records data) among the introductory and advanced level courses within the five science disciplines. The data revealed an even greater number of behavioral differences among the five science disciplines: S (shows), E (experimenting), T (transmits information), L (listens), O (observes), R (reads), W (writes notes or records data) and M (moves around the room purposefully).

Table 10 contains a summary for each selected instructor pattern. The specific instructor patterns which were selected for T- score analysis are: GLG, QLA, QLT, QLQ, SLA, TLT, TLA,

TABLE 6

Frequency of Occurrence of Individual Instructor Behaviors
College Science Laboratories (N=82)

Behavior	Introductory Laboratories					Advanced Laboratories				
	Botany N=9	Chem. N=9	Geology N=10	Physics N=8	Zoology N=9	Botany N=6	Chem. N=11	Geology N=4	Physics N=6	Zoology N=10
X Asks extended thought questions	1.8	0.0	0.1	0.0	0.5	0.1	0.3	0.0	0.1	0.1
Q Asks factual recall questions	3.6	2.8	2.3	3.0	1.9	0.9	4.3	0.8	3.4	1.5
D Demonstrates procedures	0.3	9.7	1.5	12.0	2.7	0.5	6.4	0.7	14.1	2.6
G Gives directions	0.9	8.0	2.4	7.3	2.7	0.3	6.2	1.1	3.3	4.1
S Shows	8.0	0.7	14.3	7.5	22.4	12.1	2.8	6.2	3.3	7.0
T Transmits	40.2	13.8	56.3	19.0	22.5	33.8	16.6	5.4	12.3	33.2
F Positive reinforcement	0.7	0.1	0.5	0.1	0.2	1.3	0.1	0.0	0.3	0.1
N Negative reinforcement	0.3	0.4	0.2	0.4	0.3	0.1	0.6	0.2	0.2	0.4
B Active observation	5.7	7.4	1.5	8.6	8.4	4.5	12.6	5.5	14.0	6.3
A Acknowledges	3.9	1.2	1.7	3.1	1.4	2.5	2.7	0.7	3.2	2.2
L Listens	17.9	10.9	5.6	10.6	7.0	15.9	17.8	4.3	6.1	10.4
O Passive observation	3.7	16.8	4.8	9.9	3.8	17.9	8.1	11.3	19.3	2.7
R Reads and/or writes	2.1	17.5	4.6	1.3	0.5	0.2	3.9	26.1	3.5	2.0
M Moves	3.7	1.5	0.9	4.2	11.3	3.0	1.9	6.8	4.9	6.9
Z Non-lesson	7.2	9.2	3.3	13.0	14.4	6.9	15.7	30.9	12.0	20.5

TABLE 7

Analysis of Individual Instructor Behaviors in College Science Laboratories (N=82)

Behavior	Model (df=9)		Level (df=1)		Department (df=4)		Level*Dept. (df=4)	
	F-value	Pr > F	F-value	Pr > F	F-value	Pr > F	F-value	Pr > F
X - Asks extended thought questions	3.45*	0.0014	2.87	0.0947	2.72*	0.0363	3.14*	0.0195
Q - Asks factual recall questions	2.87*	0.0060	1.89	0.1736	3.36*	0.0141	3.04*	0.0226
D - Demonstrates procedure	1.24	0.2820	0.03	0.8531	2.71*	0.0367	0.02	0.9989
G - Gives directions	4.13*	0.0003	2.48	0.1195	7.91*	0.0001	1.18	0.3276
S - Shows, illustrates	3.17*	0.0028	3.25	0.0754	4.02*	0.0052	2.27	0.0697
T - Transmits information	7.95*	0.0001	8.30*	0.0052	5.56*	0.0006	7.76*	0.0001
P - Positive reinforcement	3.59*	0.0010	0.29	0.5936	6.36*	0.0002	2.36	0.0613
N - Negative reinforcement	0.82	0.5977	0.42	0.5178	1.11	0.3606	0.66	0.6192
B - Active observation	3.37*	0.0017	1.74	0.1909	4.21*	0.0040	1.62	0.1784
A - Acknowledges student behavior	2.21*	0.0307	0.03	0.8735	2.98*	0.0247	1.78	0.1421
L - Listens	5.07*	0.0001	0.01	0.9767	8.18*	0.0001	2.23	0.0738
O - Passive observation	3.34*	0.0019	5.44*	0.0225	2.51*	0.0491	4.81*	0.0042
R - Reads and/or writes	8.37*	0.0001	1.08	0.3025	12.00*	0.0001	10.95*	0.0001
M - Gets supplies	1.87	0.0699	0.21	0.6521	2.96*	0.0253	1.09	0.3673
Z - Non-lesson-related behavior	1.71	0.1019	4.99*	0.0286	1.07	0.3753	1.86	0.1264

* Value is significant at the a priori alpha level (0.05).

TABLE 6

Frequency of Occurrence of Individual Student Behaviors
in College Science Laboratories (N=333)

Behavior	Introductory Laboratories					Advanced Laboratories				
	Botany N=37	Chem. N=34	Geology N=42	Physics N=32	Zoology N=34	Botany N=33	Chem. N=34	Geology N=18	Physics N=36	Zoology N=33
S Shows	0.2	0.1	0.2	0.2	1.9	0.5	0.2	0.1	0.4	0.8
E Experiments	36.1	35.7	12.2	30.0	31.5	33.9	55.0	46.3	39.3	40.5
L Listens	15.8	6.7	30.8	20.4	21.6	12.0	7.4	6.8	12.0	13.3
O Observes	3.1	5.3	8.8	4.4	10.3	2.6	3.5	2.8	2.5	5.3
Q Questions	1.7	2.0	2.0	2.0	2.7	2.0	1.6	1.5	2.3	2.5
R Reads	18.0	12.3	24.1	18.3	7.9	11.1	6.5	7.9	18.7	9.6
T Transmits	4.0	5.4	5.2	7.9	6.3	3.8	4.8	4.2	10.4	5.9
W Writes	9.4	11.9	11.3	12.9	11.0	28.5	3.4	24.6	9.8	10.8
M Moves	6.0	15.4	0.6	1.4	4.1	5.0	14.0	0.8	2.2	7.9
Z Non-lesson	5.7	5.2	4.8	2.5	2.7	0.6	3.6	5.0	2.4	3.4

TABLE 9

Analysis of Individual Student Behaviors in College Science Laboratories (N=333)

Behavior	Model (df=9)		Level (df=1)		Department (df=4)		Level*Dept. (df=4)	
	F-value	Pr > F	F-value	Pr > F	F-value	Pr > F	F-value	Pr > F
S - Shows	4.00*	0.0001	0.80	0.3732	4.91*	0.0007	3.70*	0.0058
E - Manipulates apparatus Observes activity	9.97*	0.0001	26.34*	0.0001	5.53*	0.0003	6.75*	0.0001
T - Transmits information	4.73*	0.0001	0.73	0.3941	10.58*	0.0001	0.04	0.9976
Q - Asks questions	0.88	0.5443	0.50	0.4808	1.56	0.1843	0.43	0.7867
L - Listens	12.19*	0.0001	28.01*	0.0001	8.68*	0.0001	7.58*	0.0001
O - Observes	5.74*	0.0001	12.72*	0.0004	7.31*	0.0001	1.53	0.1946
R - Reads	7.09*	0.0001	10.68*	0.0012	6.20*	0.0001	5.11*	0.0005
W - Writes	9.82*	0.0001	11.93*	0.0006	8.98*	0.0001	12.56*	0.0001
M - Gets supplies	13.29*	0.0001	0.02	0.8864	28.17*	0.0001	0.72	0.5818
Z - Non-lesson-related behavior	2.16*	0.0245	3.46	0.0636	1.50	0.2020	2.28	0.0608

* Value is significant at the a priori alpha level (0.05).

TABLE 10

Pattern Analysis Scores[1] for Selected Instructor Patterns[2] (N = 82)

Pattern		Introductory Laboratories					Advanced Laboratories				
		Botany N=9	Chemistry N=9	Geology N=10	Physics N=8	Zoology N=9	Botany N=6	Chemistry N=11	Geology N=4	Physics N=6	Zoology N=10
GLG	F	0.61	2.14	1.07	1.03	1.25	0.00	1.87	0.00	0.00	0.98
	I	7.00	6.75	4.00	8.00	4.50	0.00	6.19	0.00	0.00	6.67
	s	3.70	14.19	4.30	8.83	5.62	0.00	13.56	0.00	0.00	7.35
	p	0.22	0.67	0.10	0.43	0.20	0.00	0.64	0.00	0.00	0.30
	T	0.82	9.46	0.43	3.79	1.12	0.00	8.63	0.00	0.00	2.20
QLA	F	2.06	1.71	2.51	1.26	1.32	1.41	1.71	1.22	1.50	1.32
	I	3.78	4.50	3.42	3.06	5.25	4.17	4.67	3.00	3.60	3.28
	s	7.50	7.69	8.70	3.84	6.45	5.94	7.63	3.66	5.24	4.43
	p	0.44	0.11	0.60	0.71	0.40	0.50	0.64	0.25	0.83	0.60
	T	3.33	0.85	5.22	2.74	2.58	2.97	4.85	0.91	4.37	2.66
QLT	F	2.12	1.07	1.17	1.59	1.40	1.04	2.08	0.92	1.46	1.66
	I	5.84	5.80	6.40	4.66	7.05	6.75	5.93	5.00	6.25	4.54
	s	12.44	6.15	7.90	7.85	9.50	7.42	12.56	4.59	8.48	7.74
	p	0.56	0.56	0.50	0.71	0.60	0.33	0.36	0.50	0.33	0.50
	T	6.91	3.42	3.95	5.61	5.70	2.47	4.57	2.29	2.83	3.87
QLQ	F	2.16	2.05	0.53	1.71	1.20	0.56	1.87	1.22	1.39	0.79
	I	3.80	4.00	6.00	3.58	4.00	3.00	4.60	3.00	3.26	3.00
	s	8.44	8.11	3.19	6.61	4.62	1.69	10.18	3.66	4.78	2.38
	p	0.67	0.33	0.30	0.57	0.40	0.17	0.63	0.25	0.83	0.10
	T	5.63	2.70	0.96	3.78	1.85	0.28	6.48	0.91	3.98	0.24

TABLE 10 (continued)

Pattern		Introductory Laboratories					Advanced Laboratories				
		Botany N=9	Chemistry N=9	Geology N=10	Physics N=8	Zoology N=9	Botany N=6	Chemistry N=11	Geology N=4	Physics N=6	Zoology N=10
TLA	$\bar{r}$	4.27	2.13	3.41	2.04	2.81	3.86	2.13	2.08	1.91	3.25
	I	7.24	8.67	14.23	5.70	8.46	8.13	5.28	5.50	4.50	10.51
	s	33.56	21.49	41.41	11.46	17.71	25.95	11.15	11.46	9.16	41.10
	p	0.78	0.33	0.80	0.86	0.70	0.67	0.36	0.25	0.83	0.80
	τ	26.10	7.16	33.13	9.82	12.39	17.30	4.05	2.86	7.63	32.88
TLB	$\bar{r}$	1.86	1.65	0.00	0.99	1.15	0.95	1.22	1.04	1.10	2.58
	I	11.20	9.25	0.00	8.17	15.88	12.25	7.80	9.00	11.00	7.00
	s	17.77	15.07	0.00	8.23	18.82	11.63	9.54	9.37	12.08	18.04
	p	0.44	0.22	0.00	0.43	0.40	0.33	0.36	0.25	0.17	0.30
	τ	7.90	3.35	0.00	3.53	7.53	3.88	3.47	2.34	2.01	5.41
SLA	$\bar{r}$	1.51	0.00	1.53	1.14	2.77	1.95	0.00	1.13	0.00	2.34
	I	29.00	0.00	5.28	4.70	19.14	6.50	0.00	11.50	0.00	11.00
	s	43.90	0.00	8.17	5.36	56.38	12.71	0.00	13.04	0.00	29.90
	p	0.11	0.00	0.40	0.14	0.50	0.50	0.00	0.50	0.00	0.30
	τ	4.88	0.00	3.27	0.76	28.19	6.35	0.00	6.52	0.00	8.97
TBT	$\bar{r}$	2.04	2.00	1.28	2.11	1.00	1.93	2.19	1.96	1.74	1.86
	I	7.74	7.27	16.75	6.10	11.33	10.70	10.88	3.50	8.28	7.24
	s	15.75	14.39	23.57	16.50	11.52	22.35	21.92	6.27	13.47	13.82
	p	0.56	0.33	0.20	0.71	0.30	0.67	0.36	0.50	1.00	0.50
	τ	8.75	4.80	4.71	11.14	3.46	14.90	7.99	3.14	13.47	6.91

TABLE 10 (continued)

Pattern		Introductory Laboratories					Advanced Laboratories				
		Botany N=9	Chemistry N=9	Geology N=10	Physics N=8	Zoology N=9	Botany N=6	Chemistry N=11	Geology N=4	Physics N=6	Zoology N=10
TLT	F	6.48	2.65	4.84	2.74	3.39	9.75	4.49	4.24	1.88	4.56
	I	10.89	10.44	15.73	6.78	12.04	8.95	7.09	6.33	6.32	9.12
	s	75.83	21.23	77.95	21.13	37.30	89.33	37.42	28.75	11.56	45.46
	p	0.78	0.89	0.80	0.86	0.80	1.00	0.82	0.75	0.83	0.90
	T	58.98	18.87	62.36	18.11	29.84	89.33	30.62	21.56	9.63	40.91
TQL	F	2.87	1.17	2.51	1.61	1.03	0.98	1.11	0.79	1.10	1.33
	I	6.48	6.25	15.27	6.93	4.50	6.50	4.50	4.00	6.00	4.33
	s	17.97	7.24	28.62	11.33	4.64	6.32	5.03	3.17	6.59	5.57
	p	0.56	0.22	0.60	0.43	0.20	0.33	0.27	0.25	0.17	0.30
	T	9.98	1.61	17.17	4.86	0.93	2.11	1.37	0.79	1.10	1.67
TQT	F	1.43	0.90	1.67	1.27	4.17	0.74	0.00	0.00	1.59	1.16
	I	22.00	10.00	14.79	12.50	23.30	12.00	0.00	0.00	7.00	7.00
	s	28.63	9.04	26.62	19.75	97.06	9.18	0.00	0.00	11.11	8.14
	p	0.22	0.11	0.70	0.29	0.20	0.33	0.00	0.00	0.17	0.10
	T	6.36	0.99	18.63	5.64	19.41	3.06	0.00	0.00	1.85	0.81
TST	F	3.09	0.00	7.70	1.68	2.38	2.67	0.00	1.18	2.60	5.03
	I	16.20	0.00	24.60	11.67	17.83	12.94	0.00	5.50	11.15	27.25
	s	57.02	0.00	197.48	27.01	68.84	34.81	0.00	6.47	28.60	152.60
	p	0.33	0.00	0.80	0.43	0.70	0.83	0.00	0.25	0.33	0.40
	T	19.01	0.00	157.99	11.57	48.76	29.01	0.00	1.62	9.53	61.04

TLB, TLT, TQL, TQT, and TST. The summary table includes : the average frequency of each observable occurrence of the pattern ($\bar{f}$); the average total length of each observable occurrence of the pattern in tallies ($\bar{l}$); the mean score for instructors exhibiting a selected pattern (s); the proportion of instructors that exhibit the pattern (p); and, the pattern score (τ). The ANOVA results for each pattern's main effects are summarized in Table 11. The data revealed significant differences in the τ- analysis for TQL(transmits information - questions - listens) and TQT (transmits information - questions - transmits information) among the introductory and advanced level courses within the five science disciplines. Between the five science disciplines the data revealed significant differences for the following patterns: GLG (gives directions - listens - gives directions), SLA (shows - listens - acknowledges) and TLT (transmits information - listens - transmits information).

Table 12 contains a summary for each selected student pattern. The specific student patterns which were selected for τ-score analysis are: LOL, LTL, EWE, ERE, EME, ELE, ETE and WRW. Table 12 is arranged in such a way as to provide the score pattern analysis information as does Table 10. The ANOVA results for each pattern's main effects are summarized in Table 13. The data revealed significant differences in the τ- analysis for LOL (listens - observes - listens) and EWE (experiments - writes - experiments) among the introductory and advanced level courses within the five science disciplines. Between the five science

TABLE 11

Analysis of Selected Instructor Patterns in College Science Laboratories (N=82)

Pattern	Model (df=9)		Level (df=1)		Department (df=4)		Level*Dept. (df=4)	
	F-value	Pr > F	F-value	Pr > F	F-value	Pr > F	F-value	Pr > F
CLC	2.96*	0.0048	0.45	0.5060	6.25*	0.0002	0.31	0.8736
CLA	1.33	0.2342	0.06	0.8066	0.15	0.9639	2.54*	0.0469
CLT	0.50	0.8691	2.02	0.1595	0.18	0.9478	0.53	0.7174
SLA	2.17*	0.0344	0.54	0.4629	3.35*	0.0142	1.20	0.3195
TBT	0.98	0.4655	1.16	0.2844	1.79	0.1409	0.21	0.9328
TLA	2.03*	0.0479	0.74	0.3916	1.82	0.1347	2.17	0.0805
TLB	0.98	0.4660	0.37	0.5472	1.31	0.2743	0.35	0.8410
TLT	2.52*	0.0145	0.01	0.9355	4.37*	0.0032	1.35	0.2605
TQL	3.19*	0.0027	6.69*	0.0117	1.83	0.1333	1.99	0.1047
TQT	1.51	0.1599	4.56*	0.0361	0.84	0.5020	0.93	0.4534
TST	3.07	0.0037	1.93	0.1692	2.22	0.0752	2.25	0.0722

* Value is significant at the a priori alpha level (0.05).

TABLE 12

Pattern Analysis Scores[1] for Selected Student Patterns[2] (N=333)

Pattern		Introductory Laboratories					Advanced Laboratories				
		Botany N=37	Chemistry N=34	Geology N=42	Physics N=32	Zoology N=34	Botany N=33	Chemistry N=34	Geology N=18	Physics N=36	Zoology N=33
LOL	F	4.14	2.00	4.89	3.09	14.10	2.26	1.62	2.00	8.27	3.85
	T	8.98	6.67	6.30	10.87	8.49	8.44	3.43	11.29	6.62	8.49
	s	52.62	13.36	31.70	36.19	73.90	18.93	7.24	23.52	70.43	32.99
	p	0.38	0.18	0.71	0.41	0.47	0.27	0.12	0.39	0.25	0.27
	T	19.91	2.36	22.65	14.70	34.78	5.18	0.85	9.15	17.61	8.99
LTL	F	4.99	3.53	4.86	4.13	5.24	4.56	3.74	4.97	4.70	5.22
	T	5.44	5.31	8.63	4.91	6.96	6.34	5.08	8.46	4.53	5.22
	s	27.99	18.47	56.75	18.47	37.64	34.66	18.94	40.32	23.31	30.74
	p	0.59	0.59	0.62	0.56	0.41	0.58	0.59	0.44	0.67	0.67
	T	16.64	10.87	35.13	10.39	15.50	19.96	11.14	17.92	15.54	20.49
EVE	F	3.41	4.28	3.94	15.16	11.35	16.80	2.96	16.63	8.60	9.93
	T	13.06	12.88	7.41	10.46	11.23	13.32	6.16	20.09	14.44	13.71
	s	41.96	60.17	36.24	251.50	151.69	186.27	29.15	446.96	108.04	124.25
	p	0.22	0.29	0.21	0.28	0.09	0.73	0.15	0.78	0.25	0.21
	T	9.07	17.70	7.77	70.73	13.38	135.47	4.27	347.63	27.01	26.36
ERE	F	7.04	5.40	4.53	9.63	3.89	3.60	4.95	3.94	12.20	2.70
	T	21.50	12.91	8.13	28.17	21.07	16.80	10.99	24.21	26.84	14.57
	s	168.92	90.93	31.36	235.16	118.68	77.89	68.61	131.39	360.95	46.98
	p	0.41	0.62	0.10	0.09	0.32	0.45	0.47	0.39	0.44	0.21
	T	68.48	56.16	2.99	22.04	38.40	35.41	32.29	51.10	160.42	9.97

TABLE 12 (continued)

Pattern		Introductory Laboratories					Advanced Laboratories				
		Botany N=37	Chemistry N=34	Geology N=42	Physics N=32	Zoology N=34	Botany N=33	Chemistry N=34	Geology N=18	Physics N=36	Zoology N=33
	T	7.38	6.54	0.00	2.84	2.67	4.32	9.35	2.94	4.28	7.89
	Ī	22.44	15.70	0.00	11.00	14.11	15.39	19.07	30.00	14.60	24.11
[illegible]	s	199.11	108.32	0.00	22.19	38.84	60.60	191.36	88.21	90.28	223.41
	p	0.51	0.65	0.00	0.06	0.26	0.42	0.74	0.06	0.19	0.42
	⊤	102.24	70.09	0.00	1.39	10.28	25.71	159.75	4.90	17.55	94.78
	T	6.62	2.53	6.34	6.54	4.38	3.11	4.08	1.86	4.23	5.62
	Ī	17.99	8.22	7.53	8.77	10.94	8.83	20.94	14.67	7.34	17.03
ELE	s	127.53	20.36	40.27	55.55	49.31	28.50	101.85	25.07	31.95	119.28
	p	0.51	0.38	0.45	0.56	0.35	0.42	0.62	0.17	0.33	0.39
	⊤	65.49	7.78	18.22	31.25	17.40	12.09	62.91	4.18	10.65	46.99
	T	1.86	3.73	1.29	4.32	5.29	3.10	3.13	4.26	3.55	4.93
	Ī	11.40	9.10	10.56	8.92	13.47	9.11	9.77	9.00	7.33	10.73
[illegible]	s	26.49	31.84	13.51	39.53	60.76	27.47	35.89	43.69	32.22	58.63
	p	0.27	0.44	0.21	0.56	0.44	0.24	0.38	0.28	0.39	0.39
	⊤	7.16	14.05	2.89	22.24	26.80	6.66	13.72	12.14	12.53	23.10
	T	2.39	5.64	3.46	13.51	1.61	2.87	5.63	10.28	6.56	14.20
	Ī	12.80	16.64	8.83	12.83	35.00	13.72	10.80	18.00	12.24	11.80
WWW	s	27.28	116.96	31.71	208.01	56.45	46.14	60.84	157.66	77.21	223.61
	p	0.16	0.38	0.45	0.19	0.03	0.55	0.06	0.39	0.33	0.18
	⊤	4.42	44.72	14.35	39.00	1.66	25.17	3.58	61.30	25.74	40.66

disciplines the data revealed significant differences for the following patterns: EWE (experiments - writes - experiments), EME (experiments - moves - experiments), and ETE (experiments - transmits information - experiments).

SUMMARY AND CONCLUSIONS

Introduction

Controlling one's classroom or laboratory behavior is probably a function of understanding that behavior (Yeany, 1975) and that understanding comes from accurate assessment and description (Ivany and Neujahr, 1970). Assessment in college science laboratories, using explicit and precise descriptives of behaviors, provided that data in this study. The Science Laboratory Interaction Categories - Teacher (Table 2) (Shymansky et al., 1976) and the Science Laboratory Interaction Categories - Student (Table 3) (Penick et al., 1976) offer a fresh and much needed attempt to provide accurate and detailed feedback regarding the behaviors and events which take place in science laboratories at the college level. Although the Science Laboratory Interaction Categories (SLIC) were designed specifically for use in science laboratories and have been used extensively in assessing the performance of instructors and students in college science laboratories, they can be used effectively to observe and analyze the various parameters of any activity-centered or vocational education classroom or laboratory (Kyle et al., 1978).

This study was only concerned with laboratories in which graduate teaching assistants were responsible for instruction since a greater amount of total laboratory instruction at the college level is being done by graduate teaching assistants rather than experienced, trained professors. Although the science background of these instructors (graduate teaching assistants in science areas) is generally sufficient for laboratories, the level of commitment to teaching is questionable due to primary interests in research (Stokes, 1968). Shymansky (1977) notes that "when interest and commitment to teaching are low and laboratory instruction is viewed only as a job for pay . . . the quality of the resulting instruction is jeopardized" (p. 3).

Individual Instructor and Student Behaviors

As evidenced by the statistical summary tables (Table 7 and Table 9), instructor and student behaviors in college science laboratories are not consistent among science disciplines or among the introductory and advanced level courses within science disciplines. A lack of uniformity among college science laboratories implies that either: (a) due to the basic content differences between the science disciplines and levels, specific instructor behaviors and strategies are planned in advance and thus, the observed differences are actually the result of planned strategies relating to the purpose of each individual laboratory; or, (b) instructors are randomly exhibiting behaviors

in the laboratories based upon situations that arise during the course of the laboratory session -- in other words, instructors are reacting, not teaching!

If in fact the observed significant differences are planned departmental and level differences, then evidence would exist for teaching strategy sessions and instructor training sessions. Such sessions rarely exist for the purpose of training instructors in the methods of instruction at the university level. Rather, staff meetings generally focus on matters of content. It is fair to conclude then, that the observed differences and inconsistencies were not planned differences, but random occurrences.

On explanation for this apparent random behavior may be found in the lack of teaching experience of the observed teaching assistants (see Table 3) and the lack of formal educational training.

Laboratories are unique in that they get students into doing science as an investigative act instead of merely learning about science. Students have the opportunity to learn skills necessary for advanced and independent learning in science. A further advantage of laboratories which students perceive is the chance to interact freely with the instructor and with other students while working with materials.

Significant differences were found for the amount of time which students spent experimenting in college science laboratories among the introductory and advanced level courses within the five science disciplines and among the five science disciplines.

The percentage of laboratory time which students spent experimenting ranged from 12.2% to 55%. The average amount of experimenting for all observed laboratories was 36% (29.1% for introductory laboratories and 43% for advanced laboratories). Thus, slightly more than one-third of the available time is spent "doing science as an investigative act"; although the primary purpose of science laboratories is to provide students with investigative skills and procedural techniques through experimenting or manipulating scientific equipment. (Note: Since pre- and post-laboratory discussions were not coded these percentages reflect the "active" portions of the observed laboratories.)

Pavelich and Abraham (1976) maintain that "science is much more than a bunch of facts and theories. The heart of every science is research, that is, the investigation of nature" (p. 1). When comparing the percentage of time that students spent experimenting and the percentage of time that instructors spent transmitting information it appears obvious that there is less investigation of nature and more directed learning in college science laboratories than may be desired.

Statistical significance also exists for the amount of time instructors transmit information among the introductory and advanced level courses within the five science disciplines and among the five science disciplines. The percentage of laboratory time which instructors spent transmitting information ranged from 5.4% to 40.2%; however, when viewing these figures it should be kept in mind that although advanced geology instructors

transmitted information "only" 5.4% of the time, they were doing non-lessons-related behavior 30.9% of the time. Instructors transmitted information 25 % of the time on the average (30.4% for introductory laboratories and 20.3% for advanced laboratories).

Pavelich and Abraham (1976) note that the purpose of experiments is to introduce students to basic concepts of the science area and to give some experience with the scientific inquiry process. As such, students in college science laboratories should be using scientific processes such as designing experiments, collecting data, interpreting data, forming hypotheses, testing hypotheses and explaining results. With regard to scientific inquiry, Kyle (1976) notes that:

> The ability of the teacher to ask questions and to stimulate and facilitate creative and critical thinking does not enable the student to perform scientific inquiry. The ability to scientifically inquire is the personal internalized ability of an individual to synthesize the knowledge which he has obtained through the learning of basic process skills and competencies which enables a person to rationally inquire and solve problems by means of unrestrained inductive thinking. (p. 15)

Students and educators would probably agree that questioning should certainly be an integral part of science laboratories. The internalized ability of an individual to synthesize the knowledge which has been obtained through laboratory experiences must certainly involve questioning among students as well as of the instructor. Questioning by the instructor should also assist the student in the synthesis of the laboratory concepts, both during the experimental process and after the experimenting has

been concluded. Although no statistical significance was found for the amount of time students asked questions in science laboratories, it should also be noted that this behavior rarely occurred. The percentage of laboratory time which students spent asking questions ranged from 1.5% to 2.7%. Students on the average only asked questions 2% of the time -- either of the instructor or of other students. This percentage was the same for introductory and advanced laboratories.

Instructor questioning in the SLIC-Teacher system is divided into two categories: asks extended thought questions (X); and, asks factual recall questions (Q). The results for both of these behaviors are similar. Statistical significance was found for the amount of time instructors spent asking extended thought questions and factual recall questions (Q). The results for both of these behaviors are similar. Statistical significance was found for the amount of time instructors spent asking extended thought questions and factual recall questions among the five science disciplines. The data were not sufficient for differences among the introductory and advanced level courses within the five science disciplines for either behavior. Based on these data it is evident that the intellectual interaction initiated by instructor questioning behaviors is extremely low in college science laboratories. Table 14 provides a summary of the frequency of behavior X, behavior Q and the total amount of time (frequency) which instructors spent asking questions of students. Extended thought questions were asked by instructors

TABLE 13

Analysis of Selected Student Patterns in College Science Laboratories (N=333)

Pattern	Model (df=8)		Level (df=1)		Department (df=4)		Level*Dept. (df=4)	
	F-value	Pr > F	F-value	Pr > F	F-value	Pr > F	F-value	Pr > F
LOL	2.31	0.0160	5.40*	0.0208	2.32	0.0565	1.34	0.2544
LTL	1.41	0.1802	0.03	0.8699	1.44	0.2202	0.83	0.5062
EWE	7.18*	0.0001	16.83*	0.0001	7.34*	0.0001	10.13*	0.0001
ERE	3.33*	0.0007	1.51	0.2193	2.20	0.0693	4.29*	0.0022
EME	5.62*	0.0001	1.90	0.1694	6.95*	0.0001	4.70*	0.0011
ELE	2.74*	0.0044	0.01	0.9407	1.20	0.3123	4.94*	0.0007
ETE	2.27*	0.0179	0.08	0.7722	3.80*	0.0049	0.72	0.5797
WRW	1.58	0.1207	1.17	0.2800	0.68	0.6058	2.92*	0.0215

* Value is significant at the a priori alpha level (0.05).

TABLE 14

Frequency of Instructor Questioning Behaviors in College Science Laboratories (N=82)

	Introductory Laboratories					Advanced Laboratories				
	Botany N=9	Chem. N=9	Geology N=10	Physics N=8	Zoology N=9	Botany N=6	Chem. N=11	Geology N=4	Physics N=6	Zoology N=10
X Asks Extended Thought Questions	1.3	0.0	0.1	0.0	0.5	0.1	0.3	0.0	0.1	0.1
Q Asks Factual Recall Questions	3.6	2.8	2.3	3.0	1.9	0.9	4.3	0.8	3.4	1.5
Total Amount of Questioning (X + Q)	5.4	2.8	2.4	3.0	2.4	1.0	4.6	0.8	3.5	1.6

on the average of 0.3% of the total laboratory time (0.48% for introductory laboratories and 0.12% for advanced laboratories). Factual recall questions were asked more frequently -- on the average of 2.45% of the total laboratory time (2.72% for introductory laboratories and 2.18% for advanced laboratories). It is appalling to note that instructor questioning behaviors (behavior X and Q combined) ranged from a low of 0.8% to a high of 5.4% of the total laboratory time. It is apparent that instructors in college science laboratories do not feel any responsibility to either initiate intellectual discourse with students; or, factually question the student regarding procedural or experimental techniques.

The perceived student opportunity referred to earlier (i.e., interacting freely with the instructor) was unfortunately almost non-existent in the observed college science laboratories. The fact that instructors initiated intellectual discourse so infrequently could in fact have been an intimidating factor resulting in the low percentage of student initiated questions. It is apparent however, that the large amount of time which instructors spend transmitting information is not directly related to student questioning or even to follow-up discussion of questions posed initially by the instructor.

The implications are clear that even at the college level students are performing cookbookish laboratories and the role of the instructor appears to be very mechanical. The above implication is further reinforced by the amount of time students

listening. Statistically significant differences were found to exist in the amount of time students spent listening to the instructor or other students among the introductory and advanced level courses within the five science disciplines and among the five science disciplines. The percentage of laboratory time which students spent listening to either the instructor or other students ranged from 6.7% to 30.8%. Students on the average listened 14.7% of the time (19.1% for introductory laboratories and 10.3% for advanced laboratories). Since students spent very little time listening to instructor questions or student questions, the only alternatives remaining were listening to instructors transmit information (which occurs a fairly large percentage of time) or listening to other students transmit information.

The amount of time which students spent transmitting information differed significantly among the five science disciplines. Students transmitted information on the average of 5.8% of the time -- either to the instructor or to other students. This percentage was the same for introductory and advanced laboratories. Thus, it can be concluded that the nature of the activities confronting students in college science laboratories are more directly related to confirming facts and theories and gathering "correct" scientific data, rather than "the investigation of nature."

The above contention is further reinforced by the amount of time which students spent reading (R) and writing (W) in

the science laboratories as opposed to verbal interaction with the instructor and other students (see Table 15).

Statistically significant differences were found for the amount of time students spent reading and writing among the introductory and advanced level courses within the five science disciplines and among the five science disciplines. The average amount of time which students spent reading and writing combined was 26.8% (27.4% for introductory laboratories and 26.2% for advanced laboratories). In 30% of the laboratories observed, this combined frequency of reading and writing occurred more frequently than the primary objective of science laboratories -- experimenting (Table 16).

Selected Instructor and Student Patterns of Behavior

As evidenced by the statistical summary tables (Table 11 and Table 13), the selected instructor and student patterns of behavior in college science laboratories are much more consistent among science disciplines and among the introductory and advanced level courses within science disciplines than are the individual instructor and student behaviors.

Based upon these data it would appear that although the behaviors exhibited by instructors and students vary to a great extent, the nature of laboratory instruction and learning is such that sequential patterns of behavior are fairly consistent. However, it has been suggested that the patterns being exhibited

TABLE 15

Frequency of Student Reading and Writing Behaviors in College Science Laboratories (N=333)

	Introductory Laboratories					Advanced Laboratories				
	Botany N=37	Chem. N=34	Geology N=42	Physics N=32	Zoology N=34	Botany N=33	Chem. N=34	Geology N=18	Physics N=36	Zoology N=33
R Reads	18.0	12.3	24.1	18.3	7.9	11.1	6.5	7.9	18.7	9.6
W Writes	9.4	11.9	11.3	12.9	11.0	28.5	3.4	24.6	9.8	10.8
Total Amount of Reading and Writing (R + W)	27.4	24.2	35.4	31.2	18.9	39.6	9.9	32.5	28.5	20.4

TABLE 16

Frequency of Student Experimenting versus Combined Reading and Writing Behaviors in College Science Laboratories (N=333)

	Introductory Laboratories					Advanced Laboratories				
	Botany N=37	Chem. N=34	Geology N=42	Physics N=32	Zoology N=34	Botany N=33	Chem. N=34	Geology N=18	Physics N=36	Zoology N=33
E Experimenting	36.1	35.7	12.2	30.0	31.5	33.9	55.0	46.3	39.3	40.5
Combined Reading and Writing	27.4	24.2	35.4	31.2	18.9	39.6	9.9	32.5	28.5	20.4

in the observed college science laboratories reflect merely the normal responses in terms of verbal behavior to questioning procedures or when information of any kind is transmitted (Personal Communication, Michael Goldberg, Human Relations Consultant, Science Education Center, The University of Iowa, Iowa City, Iowa, May, 1976). The implication of the above is that laboratory instructors are not behaving (in terms of patterns of behavior) any differently in instructional settings than they would outside of that setting.

In effect, the logical behavioral response after asking a question (regardless of how infrequently questions are asked) is to listen; the logical behavioral response after transmitting information (regardless of how often information is transmitted) is to listen, observe, ask a question or demonstrate with regard to the information just transmitted.

The τ-score is a much more conservative means of analyzing selected patterns since not only is the frequency of occurrence taken into account; but also the length of occurrence of the pattern; and, the proportion of students that exhibit the pattern. Thus, patterns with low frequencies are not penalized if in fact they occur for longer lengths of time than do patterns which occur more often.

If further research could show that instructor laboratory patterns of behavior are no different than everyday verbal patterns of behavior, this would reinforce the contention that instructor strategy and training sessions should be a concern of science

departments at the university level. The possibility also exists that analysis of a four- or five-code collapsed sequential pattern would begin to discriminate between laboratory patterns of behavior and everyday verbal behavior.

Suggestions for Further Research

Before we as educators can accomplish the monumental task of knowing what constitutes effective teaching and which characteristics of teachers make them effective, we must observe the behaviors and interactions which are the essential component of the classroom and science laboratory. This study represents one of the first major attempts to assess the behaviors and interactions which occur in college science laboratories.

Janssen (1977) notes that an ancient adage of academic life was that professors either published or perished -- that is, they had to produce original research. He reports however, that:

> A 1975 survey of 7,798 faculty members by Seymour Martin Lipset of Stanford and Everett C. Ladd, Jr. of the University of Connecticut found some surprises: more than half had never written, edited or even collaborated on a book, and more than a third had not even published a scholarly article . . . 74% felt that teaching should be the main criterion for promotion . . . . (p. 74)

Academic deans in liberal arts colleges identified classroom teaching as the most important factor in the evaluation of faculty performance in the study of Gustad (1961) and the follow-up investigation by Astin and Lee (1966). Janssen (1977) cites James B. Moss, associate professor of psychology at Cornell, who maintains that academics in the future will be judged much

more on their teaching ability. Moss states that "Undergraduates are demanding it, state legislatures are expecting it, and tenure committees are requiring it. Teaching will improve" (p. 74).

A means of improving the effectiveness of college laboratory instruction is by being cognizant of the behaviors which are being exhibited in the laboratories. When instructors do become aware of the behaviors and interactions which facilitate the transfer of knowledge, then we will begin to be able to make rational, objective statements regarding teacher effectiveness and which characteristics of instructor classroom and laboratory behavior best facilitate meaningful learning.

As a result of this study, a number of suggestions for further research using the Science Laboratory Interaction Categories can be identified at this time.

1. This study could be replicated at several major colleges and universities, thus obtaining a larger instructor sample size and a much broader geographical region. This would eliminate any regional bias and provide a study from which broader generalizations could be inferred.
2. This study could be replicated at several four-year liberal arts colleges whose sole reason for existence is classroom teaching. This would provide for a comparative study of instructor effectiveness between the colleges established for teaching only and the institutions where research is often regarded as the primary concern.

3. College laboratory instructors could be given training in identifying different behaviors and patterns of behaviors and practice in manipulating their own teaching behaviors. This would provide for a highly controlled study in which the resultant student behaviors could be more accurately analyzed and interpreted.
4. Related studies could be undertaken to see if any sex bias exists with regard to instructor-student interactions or student-student interactions in college science laboratories; if the type behaviors exhibited by instructors are in any way correlated with the number of years of teaching experience; or, analyzing the specific instructor and student behaviors exhibited in college science laboratories with regard to whom the interaction is with. Such a study would reveal the tendency of instructors to work with individual students, and would have direct application with regard to the group dynamics in science laboratories.

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*Reference information for sources cited throughout this text is presented here along with other selected references which may be of interest to the reader of this Technical Report.

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